Docket No. GRM.P0013

SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN that I, **Mason B. Mount**, a citizen of the United States of America and a resident of the City of Mansfield, County of Richland and State of Ohio, have invented certain new and useful improvements in a

PUMP AND VALVE SYSTEM

of which the following is a specification.

PUMP AND VALVE SYSTEM

TECHNICAL FIELD

The present invention relates to a system which when operating in one mode acts as a pump, and when operating in another mode acts as a valve.

BACKGROUND ART

Pumps which meter small and precise amounts of fluid, such as in the medical field, will operate satisfactorily when the source of fluid to be pumped is below its destination, creating an "uphill" pumping situation. However, there is a problem if the source of fluid is above its effluent destination, creating a "downhill" pumping situation. In those situations, the valves in the pump will tend to bleed through, which coupled with the pumping action creates a flow greater than desired.

To date there have been no pump systems integral to one control device designed to accommodate both the uphill and the downhill pumping situations so that precise, small amounts of fluid can be allowed in flow in either situation.

DISCLOSURE OF THE INVENTION

It is thus an object of the present invention to provide a system which can operate as a pump when the inlet is below the outlet, and which can operate as a valve when the inlet is above the outlet.

It is another object of the present invention to provide a system, as above, which can intentionally allow a controlled amount of leakage when the inlet is above the outlet.

It is a further object of the present invention to provide a system, as above, in which the fluid flow can be totally closed when no fluid transfer is required.

These and other objects of the present invention, as well as the advantages thereof over existing prior art forms, which will become apparent

from the description to follow, are accomplished by the improvements hereinafter described and claimed.

In general, a device made in accordance with the present invention is selectively operable as a pump or a valve and includes a pump chamber, a fluid inlet and a fluid outlet. A valve assembly is positioned between the fluid inlet and the pump chamber and between the pump chamber and the fluid outlet. A plunger carries a diaphragm in the pump chamber. A drive member is selectively operable to either reciprocate the plunger in the pump chamber to draw fluid in through the fluid inlet and expel fluid through the fluid outlet or to position the plunger to allow fluid from the fluid inlet to pass through the valve assembly and into the pump chamber, and to allow fluid from the pump chamber to pass through the valve assembly and out the fluid outlet.

The present invention also relates to a method for moving fluid from an inlet, through a valve to a chamber, and from the chamber through the valve to an outlet. The method includes the steps of selectively reciprocating a diaphragm in the chamber to create the desired movement of the fluid or positioning the diaphragm in the chamber to permit the desired movement of the fluid.

A preferred exemplary apparatus for moving fluids according to the concepts of the present invention is shown by way of example in the accompanying drawings without attempting to show all the various forms and modifications in which the invention might be embodied, the invention being measured by the appended claims and not by the details of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-section of a device made in accordance with the present invention, showing the device in one operating position.

Fig. 2 is an enlarged view of a portion of the device shown in Fig. 1 and showing the device in another operating position.

Fig. 3 is an enlarged view like Fig. 2 but showing the device in still another operating position.

Fig. 4 is an enlarged view like Figs. 2 and 3, but showing the device in yet another operating position.

PREFERRED EMBODIMENT FOR CARRYING OUT THE INVENTION

A device which can operate as a pump or a valve is indicated generally by the numeral 10 in Fig. 1 and includes a generally cylindrical pump housing, generally indicated by the numeral 11, and a generally cylindrical control housing, generally indicated by the numeral 12. Pump housing 11 is provided with a dependent flange 13 which receives one or more screws or like fasteners 14 to attach pump housing 11 to control housing 12.

Control housing 12 defines a chamber 15 which receives the shaft 16 and other portions of a drive member, generally indicated by the numeral 17, preferably in the form of a linear actuator, and sometimes known as a stepper motor. Actuator 17 is connected to an electrical source via wires 18 and is very schematically shown in Fig. 1 in that it is a conventional item that may be purchased from several manufacturers, for example, Haydon Switch & Instrument, Inc. of Waterbury Connecticut. Actuator 17 may be attached to control housing 12 as by a plurality of screws 19 or like fasteners. As is well known in the art, actuators 17 of this type can be programmed to move shaft 16 linearly any desired amount and at any desired frequency within the mechanical limitations of the device.

A plunger, generally indicated by the numeral 20, includes a body portion 21 which has a threaded aperture (not shown) to be engaged by the threaded end of shaft 16. Thus, plunger 20 is carried by shaft 16 and is moved linearly by drive member 17. Plunger 20 also includes a neck 22 extending upwardly from body portion 21 and a flange 23 is formed at the top of neck 22.

Plunger 20 carries a diaphragm generally indicated by the numeral 24. Diaphragm 24 is a conventional elastomeric member having a peripheral bead 25 that is held in place between a rim 26 formed at the top of control housing 12 and a recess 27 formed in the bottom of pump housing 11. Diaphragm 24 also includes a lip 28 which is received in neck 22, that is, between body portion 21 and flange 23, of plunger 20. A convolution 29 is formed in diaphragm 24 between lip 28 and bead 25, and the main body 30 of diaphragm 24 extends around the top of plunger flange 23.

Diaphragm 24 isolates chamber 15 in control housing 12 from a pump chamber 31 formed by pump housing 11 when it is attached to control

housing 12. Pump housing 11 forms a fluid outlet 32 shown to be at the longitudinal end of housing 11 and thereby extends axially toward chamber 31. Pump housing 11 also forms a fluid inlet 33 which is shown as extending generally in the axial direction, as one skilled in the art would readily appreciate.

Fluid inlet 33 forms a fluid inlet passageway 34 which communicates with an annular inlet passageway 35. Annular passageway 35 communicates with, and is in intimate fluid contact with, an inlet valve chamber 36. Fluid outlet 32 forms a fluid outlet passageway 37 which is in intimate fluid contact with, and which communicates with, outlet valve chamber 38. Pump chamber 31 is in intimate fluid contact with a main valve chamber 39.

A valve assembly, generally indicated by the numeral 40, separates inlet valve chamber 36 and outlet valve chamber 38 from main valve chamber 39 and includes an umbrella portion, generally indicated by the numeral 41, and a duckbill portion, generally indicated by the numeral 42. Valve portions 41 and 42 are interconnected by an annular valve body 43 having a shoulder 44 which is received in a shoulder 45 formed in pump housing 11.

Duckbill valve portion 42 includes opposed arms 46, 47, each of which has one end extending from valve body 43 toward outlet passageway 37. The other end of arms 46, 47 touch each other, as at 48, to isolate passageway 37 and valve chamber 38 from main valve chamber 39. As will hereinafter be described in more detail, arms 46 and 47 are moveable away from each other, at ends 48, to form an opening between arms 46 and 47 at ends 48.

Umbrella portion 41 is formed by a generally cylindrical base 49 extending at one end from valve body 43 and carrying at its other end an annular umbrella leaf 50. An annular chamber 51 receives umbrella leaf 50, and the outer end 52 of umbrella leaf 50 engages an annular surface 53 in chamber 51. The inner end 54 of umbrella leaf 50 is engaged by a cup-shaped retainer generally indicated by the numeral 55.

Retainer 55 includes a generally circular base portion 56 having a cylindrical sidewall 57 extending from the ends thereof, thereby taking on the cup shape. Base portion 56 includes a central aperture 58 which permits fluid

communication between valve chamber 39 and pump chamber 31. Base portion 56 is also provided with one or more circumferentially spaced openings 59 which permit fluid communication between annular chamber 51 and pump chamber 31. Retainer 55 is maintained pressed against the inner end 54 of umbrella leaf 50 by rim 26 of housing 12 bearing against the end of sidewalls 57 with a portion of diaphragm 24 near bead 28 being positioned between rim 26 and sidewall 57.

As previously described, device 10 is intended to operate as a pump when the level of the outlet is above that of the source of the fluid at the inlet. When device 10 is thus operating as a pump, drive member 17 operates to move plunger 20 and diaphragm 24 from the Fig. 2 to the Fig. 1 position to draw fluid into device 10, and then from the Fig. 1 to the Fig. 2 position to expel fluid therefrom. Thus, when drive member 17 moves to draw fluid in, the fluid moves through passageways 34 and 35, and the pressure thereof in inlet valve chamber 36 under the umbrella leaf 50 moves its outer end 52 off of its seat on surface 53 to allow the fluid to be received in chamber 51 of valve chamber 39. As such, the fluid travels through openings 59 of retainer 55 and into pump chamber 31. When the pumping action of drive member 17 reverses to expel the fluid in chamber 31, it travels through the central aperture 58 in retainer 55 and into chamber 39. The pressure thereby exerted on the inside of the duckbill portion 42 of valve 40 separates the opposed arms 46, 47 to open end 48 and allow the fluid to pass through valve outlet chamber 38 and into outlet passageway 37.

Thus, in the pumping mode, drive member 17 is programmed to reciprocate between the Fig. 1 and Fig. 2 positions at the desired number of times per minute to meter the desired amount of fluid through outlet passageway 37. Ideally, at the end of the discharge stroke, as shown in Fig. 2, the main body 30 of diaphragm 24 is approximately 0.03 inches from a seat 60 defined by the bottom of base portion 56 of retainer 55. Of course, the volume of the fluid pumped is controlled by the length of the stroke of drive member 17.

In situations where the source of the fluid is above the final destination for the fluid, as where, for example, fluid inlet 33 is attached to a fluid source which is physically above the fluid destination, device 10 may act

as a valve. Such a condition is shown in Fig. 3. There, drive member 17 may be programmed to move main body 30 of diaphragm 24 to a location very close to seat 60, and the diaphragm 24 will stay at that position. As such, the fluid, by gravity, will move through passageways 34 and 35 to move the outer end 52 of umbrella leaf 50 off its seat on surface 53 to allow the fluid to be received in chamber 51. The fluid then travels through openings 59 in retainer 55 and into the very small pump chamber 31, the precise size of which is defined by the exact position of plunger 20 and diaphragm 24. As pressure builds up in pump chamber 31, the fluid will open the opposed arms 46, 47 of duckbill valve portion 42, and the fluid will pass through valve outlet chamber 38 and "leak" out through passageway 37. The amount of this leakage can be controlled by the position of plunger 20 and diaphragm 24 so that the precise amount of fluid leaks out through passageway 37. A typical position of main body 30 of diaphragm 24 in this mode of operation of device 10 as a valve would be about 0.001 to 0.005 inches from seat 60, which is intended to be shown in Fig. 3.

Device 10 also has the versatility to shutoff flow completely. To that end, drive member 17 may move plunger 20 and diaphragm 24 to the Fig. 4 position where main body 30 of diaphragm 24 is positioned on seat 60 to close off central opening 58 of retainer 55.

It should be appreciated that while a linear actuator has been described herein as the preferred form of drive member 17, such could be replaced by other forms of drive members such as a solenoid drive member. Such a device is shown, for example, in U.S. Patent Application Serial No. 10/174,781 filed on June 20, 2002, which is incorporated herein by reference for whatever details are necessary to fully understand the operation of a solenoid in the environment of device 10. Such a solenoid drive member includes an electromagnetic coil which reciprocates an armature in response to the energization and de-energization of the coil. The armature carries the diaphragm 24.

In the pumping mode, an oscillating signal with a variable voltage is applied to the coil. As the voltage is increased, the oscillations are larger, producing more diaphragm displacement per cycle and, therefore, more pumping volume. In the valve mode, a linearly applied voltage or current can

move the diaphragm 24 to the desired position for controlled leakage through the valve 40. As the voltage is increased in the valve mode, the diaphragm 24 is pushed toward the seat 60 to the desired position, and if moved far enough, diaphragm 24 will close off flow, being positioned on seat 60.

In view of the foregoing, it should be apparent that a device as described herein accomplishes the objects of the present invention and otherwise substantially improves the art.